

Kinetics of Pure and Mixed CO₂-CH₄ Gas Adsorption on Crushed Coal from the Black Warrior Basin, Westcentral Alabama

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A 60-gram sample of crushed Black Warrior Basin (BWB), Alabama coal (1-2 mm size fraction) was contacted with pure and mixed gases—CO₂, CH₄, a CO₂-CH₄ mixture (~50 mole % CO₂), and He—at 35 and 40°C, 324 < P(psi) < 497, to determine the rates and magnitudes of gas adsorption. The sample was loaded into a 1.2 liter autoclave suspended in a 0.5 m³, cylindrical infrared oven. Temperature and pressure were measured with ultra-high precision ($T, \pm 0.01^\circ\text{C}$; $P, \pm 0.05$ psi) and accuracy ($T, \pm 0.05^\circ\text{C}$; $P, \pm 0.1$ psi) using high-quality thermistors and pressure transducers. After vacuum drying the sample at 80°C for 36 hours, a typical “dry” experiment consisted of:

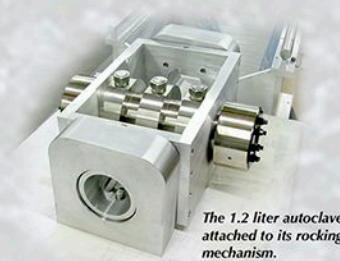
- adjusting autoclave temperature;
- evacuating the autoclave to < 1 psi;
- loading a calibrated reference volume with gas; and
- releasing the gas into the autoclave and simultaneously recording gas pressure inside the two reservoirs.

Results of 15 “dry” and water-saturated experiments are systematic, and indicate a two-step gas infiltration/adsorption process manifested by:

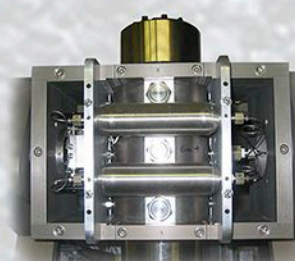
- a rapid initial pressure drop lasting <10 sec, which is attributable to pore filling and initial gas adsorption; followed by
- a prolonged period of slow pressure decrease attributable to gas diffusion and adsorption, lasting <10 hours for pure CO₂ and the CO₂-CH₄ mixture, and >50 hours for pure CH₄.

Collectively, the data indicate that CO₂ adsorption on coal surfaces is much more rapid than CH₄ adsorption. The experiments also suggest negligible adsorption of He.

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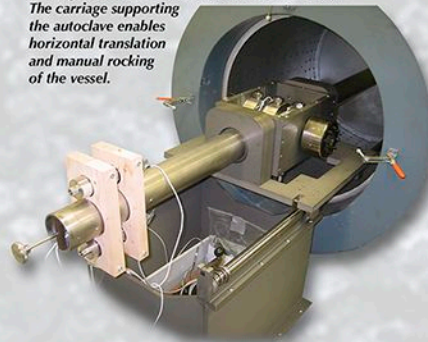


The 1.2 liter autoclave attached to its rocking mechanism.

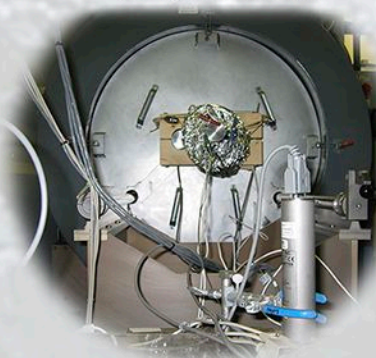


The “upstream” calibrated volume, consisting of four interconnected gas cylinders attached to the autoclave support structure.

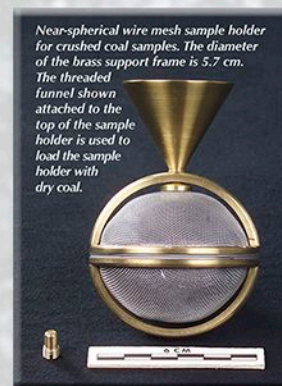
End view of the cylindrical infrared oven with insulating end covers removed. The autoclave and rocking mechanism are withdrawn from the oven. The carriage supporting the autoclave enables horizontal translation and manual rocking of the vessel.



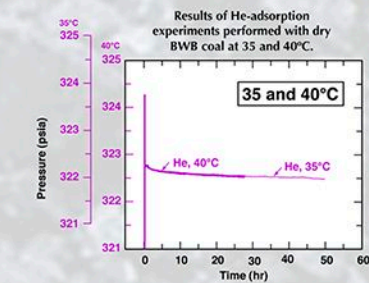
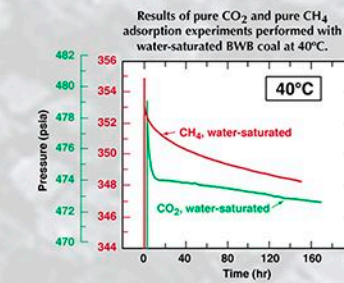
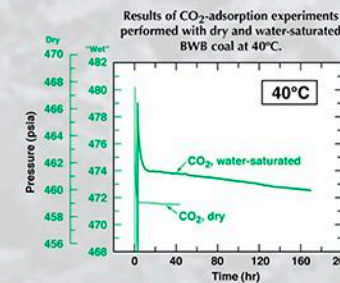
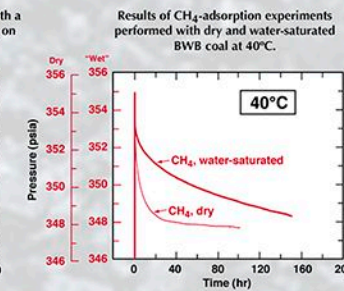
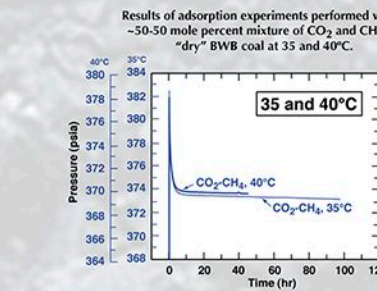
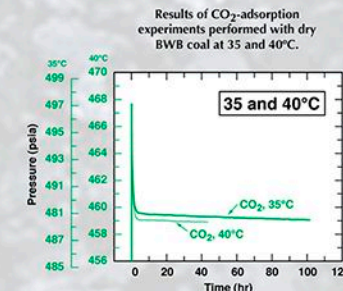
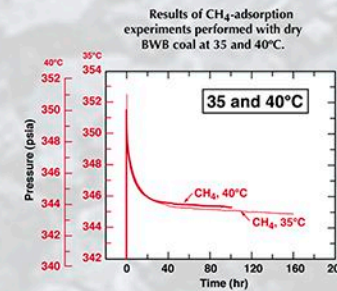
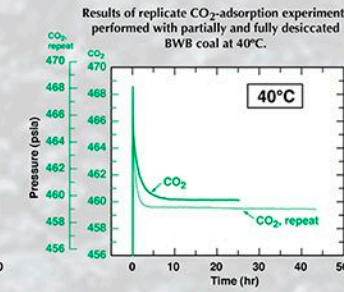
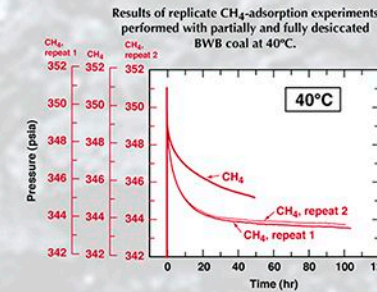
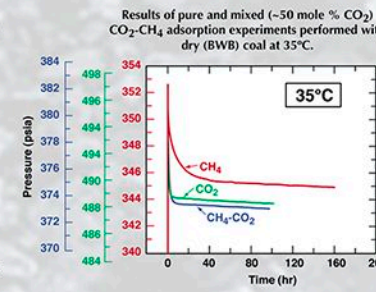
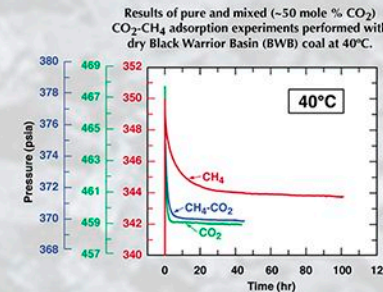
End view of the infrared oven with insulating end covers attached.



Side view of the infrared oven.



Near-spherical wire mesh sample holder for crushed coal samples. The diameter of the brass support frame is 5.7 cm. The threaded funnel shown attached to the top of the sample holder is used to load the sample holder with dry coal.



Key Conclusions

- Differential CO₂/CH₄ adsorption kinetics will play a key role in CO₂ sequestration/ECBM production in subterranean coalbeds.
- CO₂ adsorption on dry and water-saturated coal is much more rapid than CH₄ adsorption.
- Water saturation decreases the rates of CO₂/CH₄ adsorption on coal surfaces, but it appears to have minimal effects on the final magnitudes of CO₂/CH₄ adsorption!
- CO₂/CH₄ adsorption on coal surfaces is not strongly dependent on formation temperature.
- Results of our experiments suggest negligible adsorption of He on coal surfaces.